International Journal of Futuristic Trends in Engineering and Technology
ISSN: 2348-5264 (Print), ISSN: 2348-4071 (Online)
Vol. 1 (09), 2014

Process Parameters Effect of Resistance Spot Welding on Weld Quality – A Review

(Paper ID: 09ET3010201405)

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***Abstract*:** Welding engineering has undergone with a various changes in processes and materials to meet the requirement of customers and low welding cost in a present global competitive time. Large scale and high rate of production of components using sheet metal has been possible only due to resistance welding processes which have the dual advantage of making joints quickly and with minimum distortion. It is working on the principle that heat is generated by the resistance offered to the flow of current. Resistance welding processes include spot welding, seam welding, projection welding, flash welding, percussion welding, upset butt welding, high frequency resistance welding and high frequency induction welding. The process parameters affect upon Resistance Spot Welding (RSW) are welding current, resistance, time, electrode force, cooling water flow, electrode shape, sheet metal surface condition, etc. There is a various effects of process parameters interaction on final weld quality. There are different methods to get optimum weld quality by changing process parameters and their values. Artificial intelligence and neural network is also used to predict the resistance spot welded weldment quality.

Keywords: Resistance Spot Welding (RSW), Weld Quality, Process Parameters

I. INTRODUCTION

As per the requirement of different products, welding engineering has gone through a rapid development to meet the market demand. There is a high demand of products for high strength to weight ratio. Resistance Spot Welding is widely used for the fabrication of plain as well as galvanized sheet metals.RSW has techno-economical benefits such as low cost, high speed, cleanliness and simultaneously suitability for automation. It is widely used for fabrication of automotive chassis, home appliances, rail vehicles. There are 3000-7000 spot welds in car-body fabrication which require very precise process control. The weldability of galvanized steel sheet is required more attention than that of ordinary steel sheets due to spatter and electrode pollution during the spot welding.

A) Resistance Spot Welding studies

Resistance spot welding quality is influenced by process parameters and output parameters. Input parameters are welding current, resistance, time, electrode force, cooling water flow, electrode shape, sheet metal surface condition, etc. While the output parameters are tensile-shear strength, surface appearance, corrosion resistance, nugget size, etc. The RSW process output is affected by metallurgy of base metal, Heat Affected Zone (HAZ), nugget. It is also affected by weldability of sheet metal, mechanical and thermal stresses induced due to rapid heating and cooling.

Types of Resistance Spot Welding

- Series welding
- Multiple spot welding
- Pulsation spot welding

Series welding:

When a work piece is approachable to the electrodes only from one side, as in box-like construction, then it is possible to make spot welds provided a copper plate can be placed against the other side. Such an arrangement is referred to as series welding.

Multiple spot welding:

Multiple spot welding machines are used for high-volume production work such as the automotive industry. These are press-type machines in which the required numbers of electrodes are mounted usually with each electrode assembly connected to a separate transformer; however the electrodes normally operate in a sequential order so that all electrodes do not carry current at the same time.

Pulsation spot welding:

The main difference between pulsation spot welding and the conventional spot welding is that instead of a single current flow period in the weld cycle, there is an intermittent flow of current with no current flow intervals in-between. This increase electrode life and sounder welds on two pieces of steels thicker than 3mm on multiple layer welds.

B) Applications of Resistance Spot Welding

- Automotive manufacturing
- Home appliances
- Rail vehicles
- Washing machine bodies
- Refrigerator shells
- furniture

II. LITERATURE REVIEW

S.Aslanlar et.al. [1] investigated that in the joining of galvanized chromate steel sheets with 6kN electrode force, maximum tensile-shear strength is obtained at 10kA welding current in 15 cycles. When the high surface quality is prior to strength, 10kA welding current for 10 cycles welding time or 9kA welding current for 12 cycles welding time are enough.
In the joining of galvanized chromate steel sheets, maximum tensile-peel strength is obtained at 11kA welding current in 10 cycles.
S. Aslanlar [2] found that for high surface quality and high tensile-shear and tensile-peel strengths are required ,6-7kA welding current for 15 cycle welding period and 6kA welding current for 20 cycle welding period should be applied.
For high tensile-shear and tensile-peel strengths 7 and 8.5kA welding currents for 15 cycle periods are advised.
When high surface quality prior to strength, 5kA welding current for 15 cycles welding time,4.5kA welding current for 20 cycle welding time and 6kA welding current for 10cycle welding time are enough.
Murat Vural et.al.[3] revealed that increasing of the nugget diameter increases tensile-shear strength.
As per macroscopic examination, when the welding current is increased, the nugget diameter increases until a critical value.
To obtain the symmetrical weld nugget, the weld current should be increased or the electrode tip diameter on the galvanized steel sheet should be decreased so that current density increases at this side.
The maximum hardness values are in the middle of the weld nugget and more than 350V in a some areas of the weld nugget.
S. M. Hamidinejad et.al.[4] found that the regression analysis reveals that there is a non-linear relationship between the welding parameters and the tensile-shear strength of the RSW joints.
The effects of welding parameters and their interaction on the tensile-shear strength were analyzed on the basis of the ANN model. This can provide a beneficial for the RSW process of galvanized interstitial free(IF) steel sheets and galvanized bake hardenable(BH)steel sheets.
Spitz et.al.[5] found that superior weldability of lubricated hot-dip galvanized steel sheet surfaces related to:
-Absence of surface lubrication led to the formation of a non/low electrical contact layer (e.g.Al_2O_3) on the welding electrode cap surface.
-Surface lubrication minimized the interaction of zinc and aluminium with the welding electrode cap. Electrode life could thus be increased.
-Sticking of the welding electrode cap was hindered in the presence of lubrication.
Ugur Esme [6] revealed that for SAE 1010 steel sheets, based on ANOVA method, the highly effective parameters on the tensile strength were found as welding current and electrode force, whereas electrode diameter and welding time were less effective factors.
The results showed that welding current was about two times more important than the second ranking factor (electrode force) for controlling the tensile strength.
An optimum parameter combination for the maximum tensile-shear strength is obtained by using the analysis of signal-to-noise(S/N) ratio.
D. S. Sahota et.al. [7] Investigated that for ASS316 by increasing weld current, weld time and electrode force results in an increase in weld nugget diameter and width.
An increase in weld current, weld time and electrode force results in an increase in electrode indentation.
A. K. Pandey et.al. [8] Revealed that for low carbon cold rolled 0.9mm mild steel sheets,
-By experimental results the selection of input parameters are: medium current (6.8kA), medium pressure (0.79KPa) and high holding time (5 Seconds).
-The response of S/N ratio with respect to tensile strength indicates the welding current to be the most significant parameter.
-The contribution of welding current, holding time and pressure towards tensile strength is 61%, 28.7% and 4% respectively as determined by ANOVA method.
A.G.Thakur et.al. [9] found that for Galvanized steel sheets,
-Based on ANOVA method, the highly effective parameters on tensile shear strength were found as welding current and welding time.
-The welding current was about two times more important than the second factor weld time for controlling the tensile shear strength.
Mr. Niranjan Kumar Singh et.al. [10] Found that for AISI 301L stainless steel,
-Based on ANOVA method, the highly effective parameters on indentation are found as weld cycle, interaction between weld current & weld cycle, interaction between weld current, weld cycles & hold time whereas weld current, hold time and cool time were less effective factors.
-The experimental results confirmed the validity of Taguchi method for optimizing the process parameters in resistance spot welding.

III. METHODOLOGY OF RESISTANCE SPOT WELDING

A) Working principle of RSW

RSW process differs from other welding processes in that no fluxes are employed, the filler metal is rarely used, and the joints are often the lap type. The heat generated is given by,
$H=I^2RT$
Where H=Heat generated, joules
I =Current, amperes
R=Resistance, ohms
T= Time of current flow, seconds
In RSW process a low voltage, high amperage current flows from one adjoining plate to the other until the metal at the interface is heated to a high enough temperature to cause localized fusion which under the applied pressure squeezes the

molten metal from the two parts to a homogenous mass called the weld nugget.

B) Advantages of RSW

-Used to join metal sheets from 0.5 to 4mm.
-No filler requirement
-Good surface quality of welded surface
-Mass Production
-Automation is possible
-Fast process

C) Limitations of RSW

-Majority used for lap joints
-Only for joints which are accessible by electrodes of RSW machine.
-Precise control of process parameters to obtain good quality weld.
-Thicker sections are more difficult to weld
-The metals with high resistivity, low thermal conductivity and low melting point are easily weldable. While other metals and refractory metals are difficult to weld.

IV. CONCLUSION

From the different research papers we conclude that many optimization methods for process parameters effect of RSW on welding quality are found out.RSW process output is affected by input process parameters and their interaction. Out of the different methods Taguchi method for optimizing the RSW process is found Applicable for RSW process design to obtain weld quality.

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